GAS HEAT in INDUSTRY

10/6 Per Annum — Formerly INDUSTRIAL GAS TIMES — DECEMBER, 1950

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GAS HEAT *in* INDUSTRY

Vol. XIV December, 1950 No. 159

The Application of Gas Firing to a Hospital Refuse Destructor

A PROBLEM confronting the authorities of a local hospital was how to effect the rapid and complete destruction of refuse from wards, operating theatres and other departments. Such refuse consisted mainly of surgical dressings, plaster casts, cotton wool, dead and wet flowers, papers and occasionally small surgical cuttings and amputations.

The plant available was a Meldrum's No. 3A standard, natural draught destructor, capable of dealing with 180 lb. of refuse per hr. The method of operating was simply to ignite the first binful of refuse and when well alight, add further binsful until the destructor was full. Natural chimney draught was then expected to complete the incineration.

It will be readily appreciated that such articles as wet, soiled dressings and cotton wool, plaster casts and damp flowers do not readily lend themselves to rapid disposal. This, coupled with the fact that the hospital ward staff was depleted and consequently had little time to spare for attention to the destructor, often led to refuse congestion and finally smothering in the destructor, or being reduced to a slow rate of smoulder. Because of this, use had often to be made of one of the hospital's boilers to relieve rubbish congestion.

The destructor had to cope daily with the refuse from ten wards, with a total of 177 beds, a casualty ward, two operating theatres, physiotherapy department and nurses'

MAIN FEATURES IN THIS ISSUE

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home. This represented a total of six binsful weighing a total of 5 cwt. Half of the quantity was dealt with in the morning and the remainder in the late afternoon.

In considering the problem, it was generally agreed that combustion needed to be under forced draught partly to counteract the conditions arising out of congestion and partly to assist in accelerating the disposal of any organic matter present. In addition, it was also agreed that provision for forced draught should be made below firebar level in the ash pit to complete the combustion of particles small enough to fall between the bars.

It was felt that the best position for the burner would be at the front of the destructor in place of the firedoor. Reasons for choosing this position were as follows:

(i) The position afforded some protection against rubbish falling against the burner when being charged. The design of the destructor and slope of the firebars from front to back helped to preclude such a possibility.

(ii) Firing below firebar level would give rise to possible distortion of the firebars; the sole purpose of which was to retain as much as possible in the incinerating zone, and passing only the smallest particles and ash into the ashpit. Difficulty in removal of the ash would also be created.

The burner chosen was a Gako type W.B., G8/141/7, manufactured by Liptak Furnace Arches Ltd., designed to operate on forced draught and having a capacity of 350 c. ft. per hr. with air and gas pressures of 2 in. w.g. A 20 in.

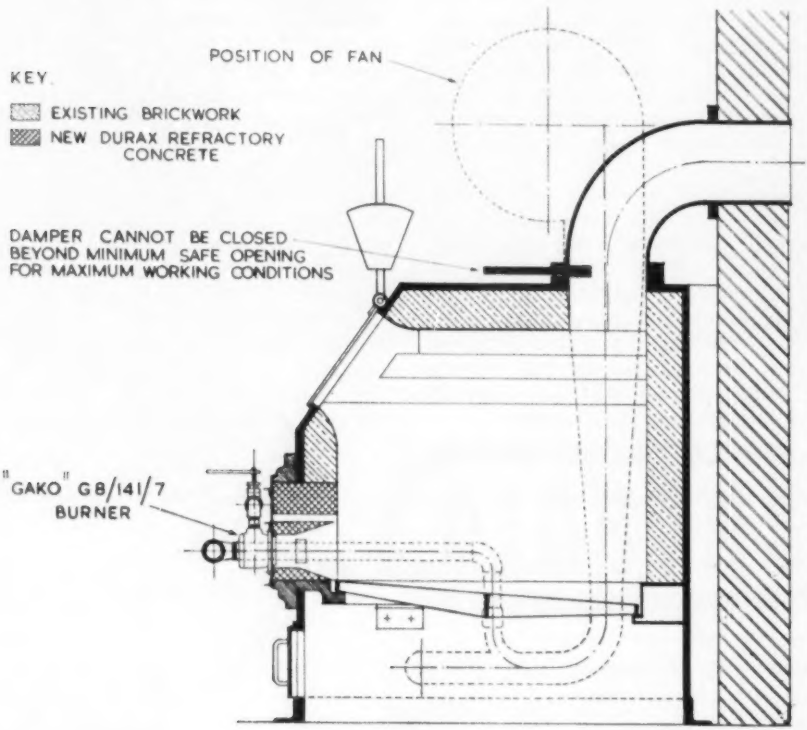

POSITION OF FAN
KEY
EXISTING BRICKWORK
NEW DURAX REFRACTORY CONCRETE
DAMPER CANNOT BE CLOSED BEYOND MINIMUM SAFE OPENING FOR MAXIMUM WORKING CONDITIONS
"GAKO" G8/141/7 BURNER

Fig. 1

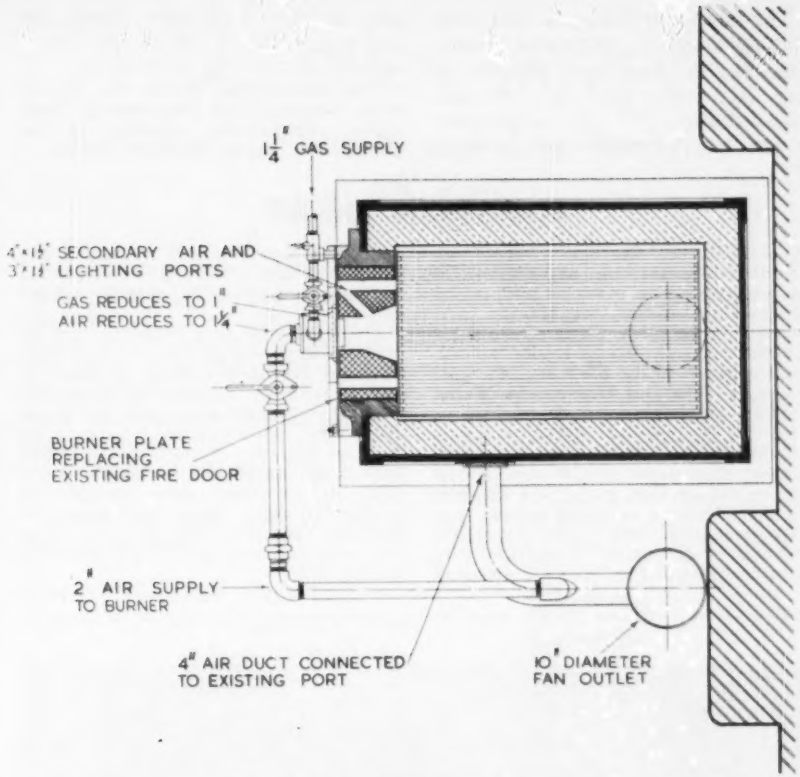


Fig. 2. Key is similar to that for Fig. 1

single stage centrifugal blower with a 10 in. dia. discharge, and driven by a ½ h.p. motor, was used. The flue damper is arranged so that it cannot be closed beyond the minimum safety opening.

A general arrangement is shown in Figs. 1 and 2.

The installation has given complete satisfaction over the period of 3 years since the adoption of gas firing.

The following is a test recently carried out which illustrates the effectiveness of the destructor and the rapidity with which refuse was reduced to removable ash.

Quantity of material destroyed (three bins), 200 lb. approx.; Nature of material, soiled dressings, flowers, straw, general rubbish, body plaster, three leg plasters, one arm plaster; Gas turned on 3.15 p.m., Gas turned off 3.20 p.m.; Gas and air pressures 2 in. w.g.; Gas consumed 28 c. ft. (14,000 B.Th.U.); Specific gravity 0·54; Refuse destroyed completely and ash removed 3.45 p.m.

From 3.20 p.m. to 3.45 p.m. the destructor operated solely on forced draught issuing from burner nozzle and from air nozzle below the fire bars.

It should be noted that surgical cuttings and small amputations would naturally take longer, with a consequent higher gas consumption. A great proportion of the above material was very damp and would have proved difficult to reduce to ash under natural draught conditions even over a period of hours.

The above problem is one confronting many hospitals and institutions but is capable of solution at very low cost both in fuel and initial outlay, and this application of gas has increased the throughput of the incinerator from the maker's rating of 180 lb. per hr. to approximately 200 lb. in ¼ hr.

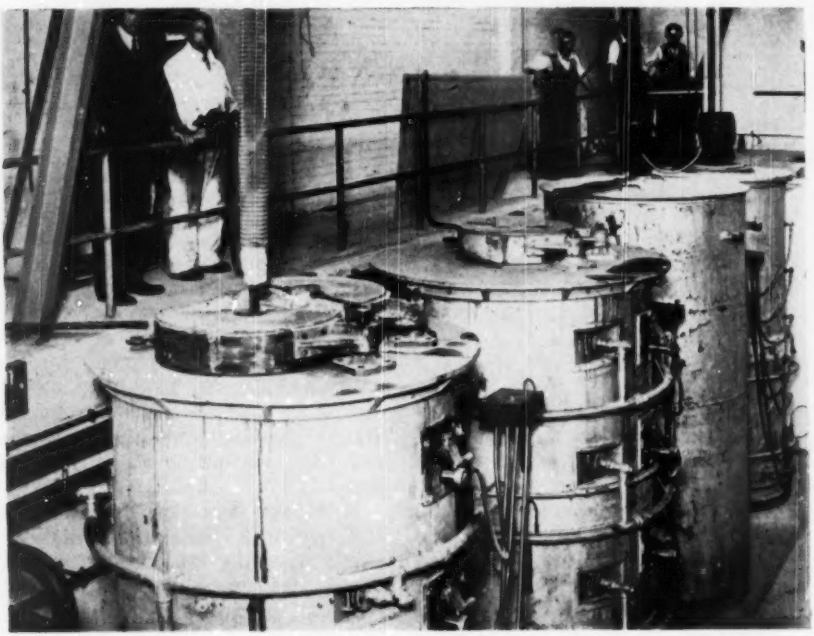
Reproduced from Report No. 50/1/27 D 18, Industrial Gas Development Committee. Information supplied by the Eastern Gas Board, Watford Division.

DISCOVERING AIRDRIE

AIRDRIE, in Scotland, offered an interesting example of "selling" its gas undertaking, in October, when the "Discovering Airdrie" exhibition was launched in the town. Idea of the show was that research groups should investigate the trends in the town over the past 100 years. The Gas Department offered a picture of development from 1940 to 1950. In that period output increased three times to 1,789,000 therms. Prices dropped 10 per cent. in the same period from 4s. 3d. in 1940 to 3s. 10d. in 1950, although the price of coal doubled.

To give some idea of the trend the exhibition incorporated important new plants installed in the town, all potential or actual consumers of industrial gas. Models of new plant, and a Wests unit, and two Henry Balfour models were on show.

This exhibition quite different from the normal shows organised to sell gas, offered a factual picture of gas development in the town, alongside a whole mass of similar related data referring to all other civic developments. Other communities, unaware of the romance behind their development, and possibly as energetic in providing new services as Airdrie has been, might well copy this excellent piece of research work to ensure full appreciation of all that gas means in modern life.



A battery of gas-fired steel hardening equipment used by the Lapointe Machine Toole Co. Ltd. in the manufacture of broaches, which includes a preheat furnace, super-heat furnace, quenching tank and tempering furnace. A tungsten steel broach, 70 in. in length and about 4¼ in. diameter, is seen entering the preheat furnace

GAS OVEN SAFETY

Automatic Pilots and Low-Pressure Cut-off Valves

IN gas-heated industrial equipment safeguards against gas explosions are essential. They are often described as "flame failure devices," "automatic pilots," is prefered, since flame-failure is not the principal cause of explosions in modern gas-heated equipment. In fact, two-thirds of the accidents occur during lighting-up.

These "automatic pilots" are of three main types:

Thermal Expansion Type

With this type the heat of a pilot flame is applied to a "thermal element," which expands and opens a gas valve, allowing gas to flow to the burner where it is ignited by the pilot flame. With flame-failure, cooling and consequent contraction of the thermal element closes the gas valve.

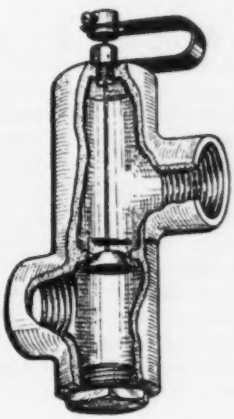
The thermal element is usually of two parts, one of which expands more than the other when heated. It may be a rod made of invar steel or silica which expands very little, placed inside a tube made of a material which expands considerably on heating. The rod and tube are joined at one end and the relative increase of the length of the tube compared with the rod when heated by the pilot flame operates a valve mechanism attached to the other end of the tube and rod.

Bimetallic Strip

On the other hand a bimetallic strip consisting of two dissimilar metals is used. A differential expansion causes the strip to bend when heated and to regain its former shape when cooled. The alteration in shape of the bimetallic strip is used to open or close a gas valve (Fig. 1).

A liquid is sometimes contained in a metal tube. Heat applied to the tube causes the liquid to expand more than the tube and the pressure generated is used to operate a gas valve, by means of a switch controlling an electrically operated solenoid valve (Fig. 2).

Thermal elements, as in the first



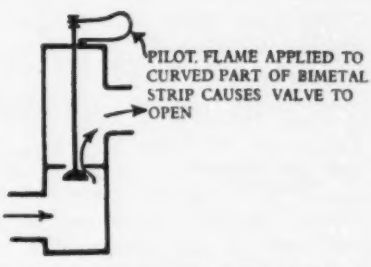


Fig. 1. Simple automatic pilot device—bimetal type

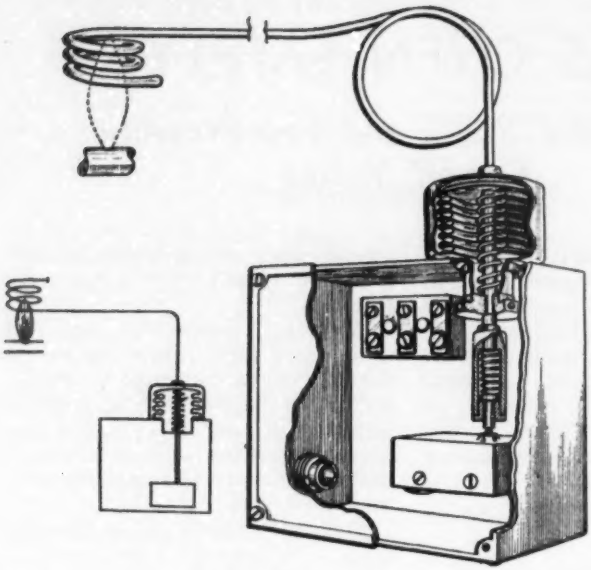


Fig. 2. Automatic pilot device—liquid expansion type

(Courtesy, British Thermostat Co. Ltd.)

two examples, are relatively slow in operation when mechanically linked to a gas valve and, in the past, they have been used mainly on small plant. A recent development is the employment of a bimetallic element to operate a switch controlling an electric valve.

Thermocouple Type

Here the action depends upon the current generated if two pieces of wire of different materials joined together at their two ends have one junction heated. The electric current can hold a small electromagnetic valve, controlling the gas supply to the burner, in the open position after the valve has been opened manually, or it can maintain a switch in an electrical circuit after the switch has been closed manually. In the latter case the switch can be made to control an electric valve in the gas pipe to the burner. If the pilot flame which warms the "hot" junction of the thermocouple is not properly established, or is established and then later extinguished, accidentally or otherwise, the ther-

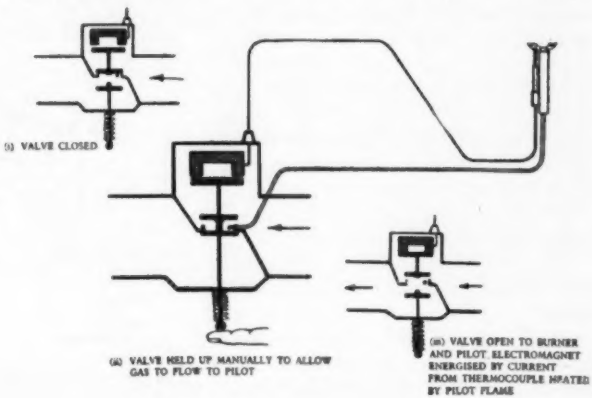

(i) VALVE CLOSED
(ii) VALVE HELD UP MANUALLY TO ALLOW GAS TO FLOW TO PILOT
(iii) VALVE OPEN TO BURNER AND PILOT ELECTROMAGNET ENERGISED BY CURRENT FROM THERMOCOUPLE HEATED BY PILOT FLAME

Fig. 3a. Automatic pilot device—thermocouple type

(Courtesy, Honeywell-Brown Ltd.)

mocouple junction cools, current ceases to flow and the valve(s) controlling the gas supply to the burner and pilot close(s) automatically (Fig. 3a and b).

Flame Electrode Type

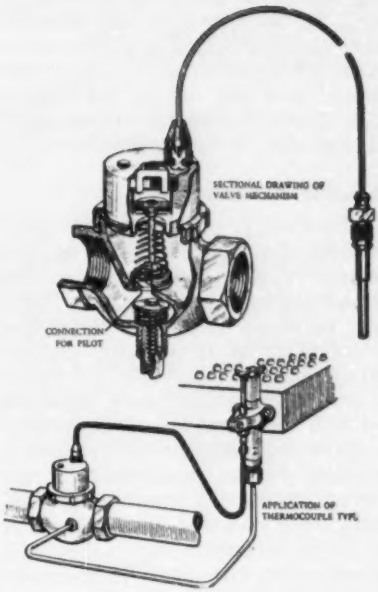
The action of this type is due to the ability of flames to conduct electricity. Thus the pilot and burner flames become part of an electric circuit. The circuit includes a thermionic valve amplifier and controls electrically-operated gas valves in the supply pipes to the pilot and main burner. Lighting up in the first instance can be by manual ignition of the pilot flame or by automatic spark ignition. If the flame is not established or fails, the gas supply to pilot and burner is immediately stopped (Fig. 4).

The flame electrode type of automatic pilot is readily adapted to form part of a combustion control system which ensures automatically (usually by means of a time switch and an air - flow switch), in mechanically ventilated ovens, a purging of the combustion and oven space with fresh air before lighting up the burners and also the stoppage of the gas supply if the system of oven ventilation stops working.

Points to Consider

The best automatic pilot devices control the gas to the pilot as well as to the burner (Figs. 3, 4 and 6), but on small plant, where the quantity of gas that can escape from the pilot is small a device controlling only the gas to the burner may be used.

The automatic pilot system should be almost immediate in action between the extinction of the pilot flame and the automatic closure of the gas-control valves. The flame electrode type is practically instantaneous but the other types can be made fairly rapid in action. It is important that thermal expansion elements and thermocouple "hot" junctions should be installed



(Courtesy, Honeywell-Brown Ltd.)

Fig. 3b. Automatic pilot device

in such a manner that they will cool quickly, if flame-failure occurs and will not continue to receive heat by radiation or otherwise, from hot brickwork or metalwork.

The importance of speed with which an automatic pilot operates to secure a "shut down" depends on the size and type of plant, the efficiency of its ventilation and the rate of gas-flow to the burners. A device that is not very rapid in action as regards flame failure may still be of considerable value as a safety device if it will prevent escape of unburnt gas during the lighting-up operation.

The pilot should be securely fastened and carefully positioned with regard to the burner, so that the pilot flame will always ignite the burner gas, even if the gas supply has been turned low or has been reduced from any other cause. Pilot flames should be stable and not

exposed to undue draught, so that it may be necessary to use draught shields. The valve(s) of the automatic pilot system should be on the supply side and not on the burner side of any thermostat valves which operate the "weep" principle.

Periodic Examination

Mechanism of automatic pilot systems should be arranged so that failure of any part results in the stoppage of the gas supply. If the gas valve is electrically operated interruption of the electric current should cause the valve to close. Some automatic pilots operate through diaphragm valves, similar to those used for thermostatic control working on the principle of a gas "weep" through a small orifice. If this orifice becomes blocked by dirt or gum formation the valve will remain open even after flame-failure has occurred. Blockages of this kind are not of frequent occurrence but the valves should be constructed so that the weep orifice can be readily examined and cleaned. All equipment should be examined and cleaned periodically.

Automatic pilots should be used in conjunction with gas cocks of a type approved by the gas undertaking. These cocks should be closed manually when the plant is shut down. Finally, suitable observation ports should be provided so that the operator can readily observe the burners and pilots and in this respect a reflector is sometimes useful.

Low Pressure Cut-off Valves

Many gas explosions occur because gas has been turned off at a main cock while burner cocks have been left open or partly open. There is the obvious danger that the main cock may be turned on, but no attention given to the burner cocks, and by the time a light can be applied to the burners enough gas may have entered the oven to cause an explosion. The possibility of such an accident is increased where a number of local cocks are controlled by one main cock.

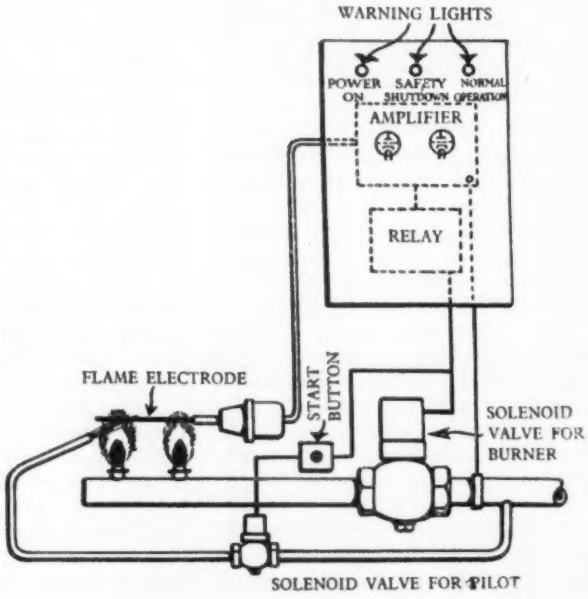
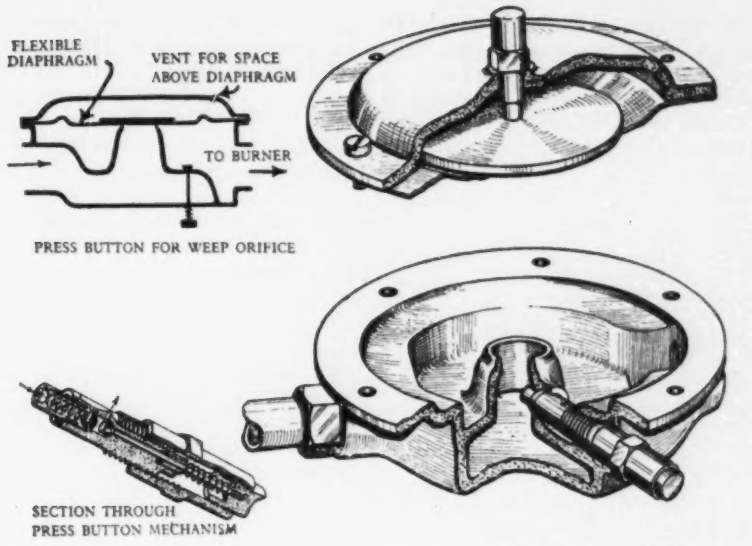


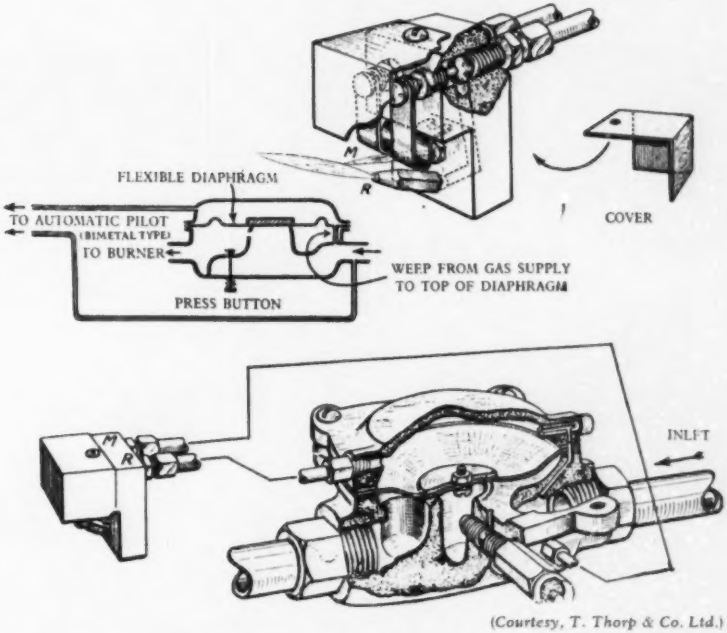
Fig. 4. Automatic pilot device—flame electrode type

(Courtesy, Honeywell-Brown Ltd.)



(Courtesy, Keith Blackman Ltd.)

Fig. 5. Low pressure cut-off valve



(Courtesy, T. Thorp & Co. Ltd.)

Fig. 6. Automatic pilot device and low pressure cut-off valve combined

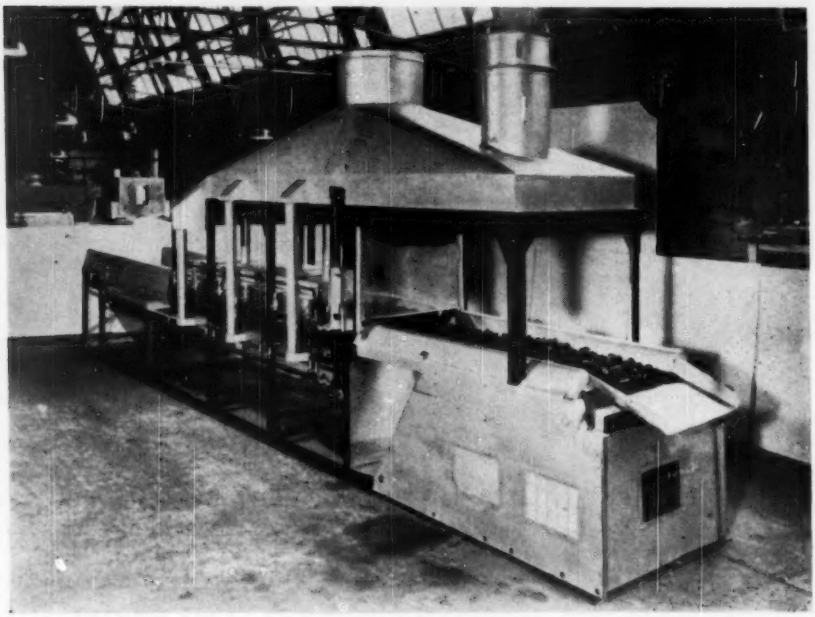
An unexpected and unnoticed extinction of burners after lighting, due to a drop in the gas supply reaching the burners is another cause of explosion. A dangerous decrease of pressure in gas mains is rare, but a local pressure drop, due to the starting up of other gas equipment is frequent.

These examples account for nearly a third of the gas explosions reported. They are all due to a fall of gas pressure in the pipes supplying the burners, and in all cases a low pressure cut-off valve would provide an effective safeguard. These are usually of the diaphragm type, but can also be operated electrically.

A diaphragm type of cut-off valve is illustrated in Fig. 5. Normal gas pressure applied to the underside of the flexible diaphragm is sufficient to hold the valve open. The diaphragm is so weighted that when the gas pressure falls below a safe limit, or when gas is turned off at a main cock and burner cocks are left open, the valve drops to the closed position. As the area of the valve is small, compared with that of the diaphragm, restoration of the gas pressure to normal does not cause the valve to re-open. The valve cannot be re-opened, even after the gas pressure on the inlet side has been restored, until the burner cocks have been closed. The operator has to close the burner cocks and then press the reset button on the valve before lighting up.

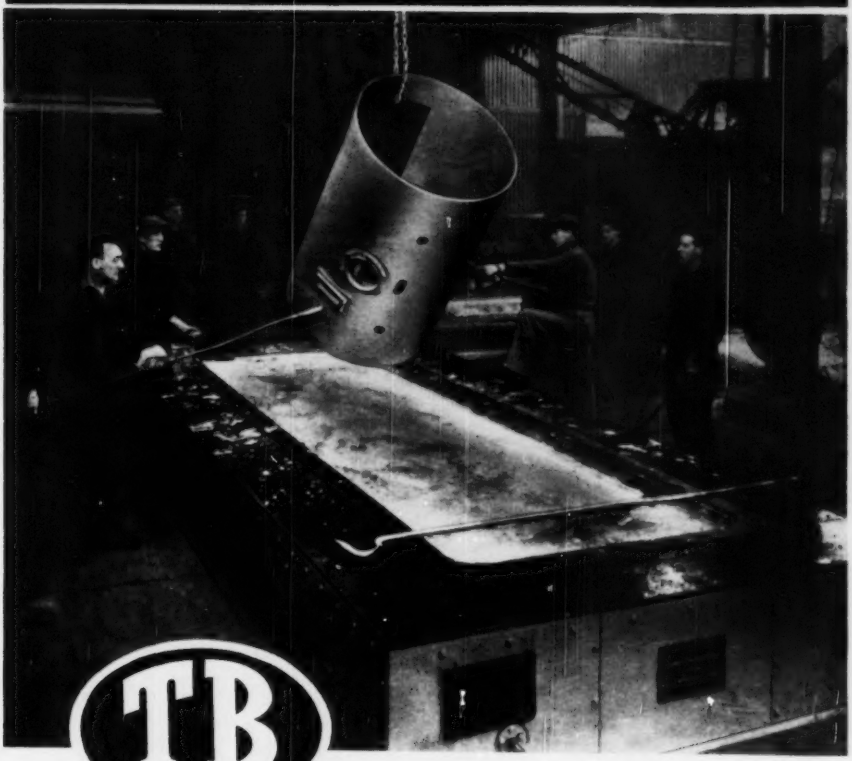
The low pressure cut-off valve should be on the inlet side of the temperature control device (if there is one) and as near as possible to the appliance, and of course, low pressure cut-off valves can be incorporated as part of automatic pilot systems (Fig. 6).

("Safety in Design and Operation of Gas Heated Ovens and Furnaces." H.M. Stationery Office.)



A Potterton type gas-fired radiant heat installation for drying metal film spools

MODERN GALVANISING TECHNIQUE



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Drying of Relief and Die Stamped Letter Headings

THIS is a problem confronting many printers undertaking die stampings, because of the considerable period needed to dry in the atmosphere. The periods required for air drying vary from 12 hours for black to 4 or 5 days for mauve.

Colours are not normally sensitive to the long wave radiation generated by medium temperature panels but the difference in composition of the various coloured inks affects the drying time. In this connection it has been found that standard brown and mauve will not dry quickly under the influence of radiant heat.

The ink composition in this case is such that a process other than a thermo-accelerating one is necessary to dry it.

From results of tests undertaken, satisfactory drying is governed by the following factors:

(a) Type of ink (this may vary considerably according to the amount of drying agent introduced by the makers, even with inks of similar colour).

(b) Proportion of varnish used with the ink.

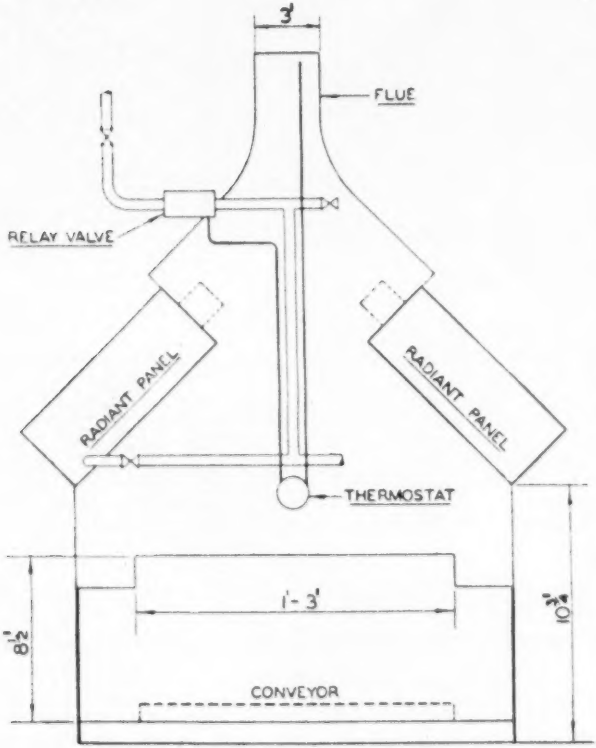

Fig. 1. Showing the design of the heater, made from standard heating units

Automatic Press Producing Silica squares.

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RESULT OF TESTS ON TWO MACHINES

	1	2
Type of paper	Everest (hard surface)	Stag Bond (medium surface)
Type of ink	Black Die Press ink (Dane & Co., London) mixed with Winstones Varnish M.F.8309, 1 pt. varnish to 1 lb. ink	Die Stamping blue (Frank Horsell & Co. Leeds) mixed with varnish as test No. 1
Air temperature	65° F.	65° F.
Length of heating zone ...	23 in.	23 in.
Conveyor speed	3 ft. 9 in. per min.	3 ft. 9 in. per min.
Time spent in heating zone ...	30 sec.	30 sec.
Gas pressure	3 in. w.g.	3 in. w.g.
Max. gas rate per hour	42 c. ft. 21,000 B.Th.U.	42 c. ft. 21,000 B.Th.U.
Actual gas rate per hour ...	27·8 c. ft 13,900 B.Th.U.	28·8 c. ft. 14,400 B.Th.U.
Calorific value (nominal) ...	500 B.Th.U./c. ft.	500 B.Th.U./c. ft.
Specific gravity	0·57	0·57
Mean panel temp. (left hand) ...	657° F.	666° F.
Mean panel temp. (right hand)	666° F.	662° F.
Temp. of heating zone (paper level)	120° F.	125° F.
Throughput quarto sheets per hour	1,600	1,600
Result	Completely dry	Completely dry
Relative time for air drying ...	12 hours	24 hours
Remarks	Slight shrinkage, very slight tendency to curl which soon disappears on cooling.	Slight shrinkage, very slight tendency to curl which soon disappears on cooling.

(c) Type of paper.
(d) Depth of lettering.
(e) Composition of the ink.

A further aspect of the problem was also revealed, as a result of initial experiments, in that artificial or radiant heating is not suitable for speedy drying of multi-colour relief stampings. Paper which has been subjected to radiant heat undergoes shrinkage, which although barely perceptible is sufficient to throw any succeeding stamping out of register. Consequently it is not possible to carry out a sequence of stampings and dryings as a continuous process. To overcome this drawback it would

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appear that slight humidifying of the heating zone is necessary to counteract the tendency of moisture removal taking place from the paper. No experiments along these lines have as yet taken place.

Standard Unit Installation

The following describes an installation made from standard heating units.

The design of the heater is shown in Fig. 1. Potterton infra-red gas unit panels are superimposed on an angle iron and sheet metal frame, so designed as to fit easily over a conveyor belt situated adjacent to each die press machine. It is a simple matter to adjust the height of the heaters above the belt.

The unit is served with a ½ in. B.S.P. gas supply, pressure regulation being accomplished by a ½ in. Bryan Donkin governor. Temperature control is effected by means of a Spersom thermostat, type TW702, fitted in the radiant zone, operating through a ½ in. relay control valve.

Reproduced from Report No. 50/1/26, D230, Industrial Gas Development Committee.—Information supplied by the Eastern Gas Board, Watford Division.

THE MANUFACTURE OF TEAPOTS

Gas Aids Dollar Export Orders

WHAT is believed to be the largest single order ever executed by an English teapot house for the dollar market was a consignment of 180,000 brown teapots recently dispatched from the Burslem factory of J. Sadler and Sons Ltd. The size of this order was sufficient for a complete trainload, and it was dispatched in three sections, involving 5,000 cartons contained in 313 large cases, and with an overall weight of 100 tons.

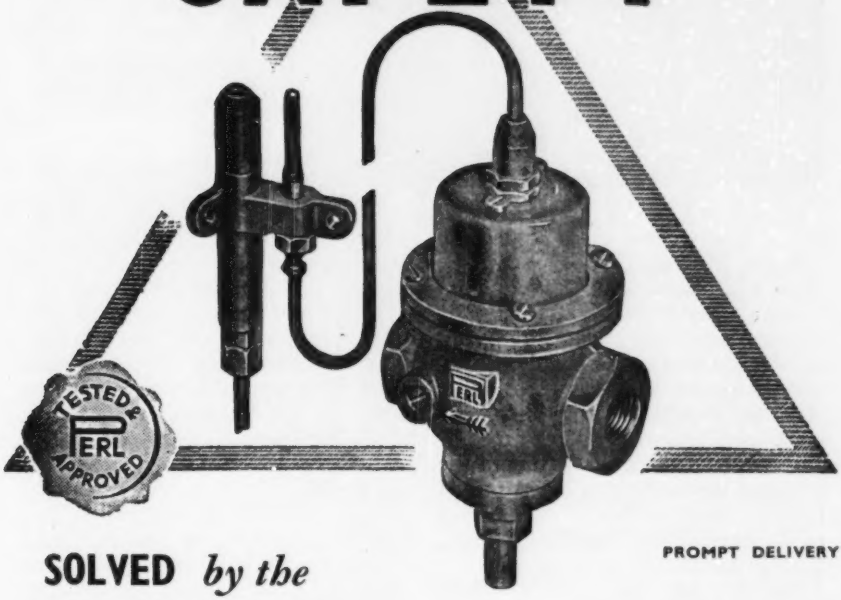
Recent Extension

To carry out orders such as this, the firm's most recent development has been the erection of a large three-story extension, housing most of the processes involved in teapot produc-

The casting shop. Two electric blungers are in the background, while the biscuit oven is to be seen behind the stillages on the right

Ignition and Combustion

SAFETY



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A view of the enamel kiln showing a group of cars loaded with teapots waiting to enter the tunnel

tion. The ground floor contains a modern sliphouse, a large casting shop, and also accommodates a continuous, gas-fired biscuit kiln by International Furnace Equipment Co. Ltd., and a continuous gas-fired glost kiln by Gibbons Bros. Ltd. Both are capable of firing biscuit or glost ware according to the needs of current production. A feature of the adjacent dipping-house is the use of tubular steel stillages, which are easily moved and capable of being quickly extended as required.

On the top floor the on-glaze decorating shop has been planned to accommodate 250 operatives, the varied decorations being mainly applied free-hand, whilst the middle floor contains a decorator kiln, which is also gas-fired, built and erected by Gibbons Bros. Ltd.

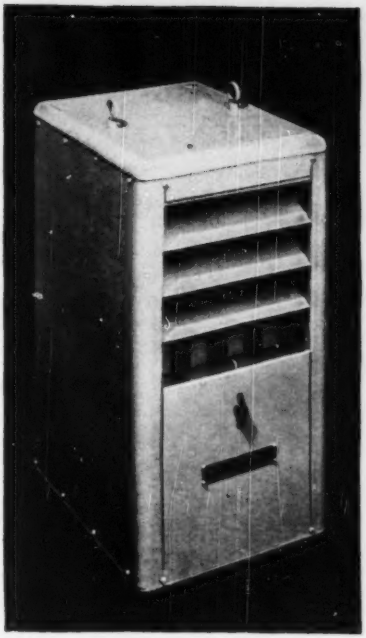
From the kiln the teapots are transferred to the cellophane wrapping department, a feature of the firms sales appeal policy, and from there to the finished ware-house, ready for dispatch as required.

Glost Kiln

The Gibbons Bros. Ltd. Glost kiln is an open flame Dressler multi burner kiln fired by town gas for the firing of glost teapots in saggars. The kiln is designed with a firing temperature of 1,130° C. at the top of the car, and special provisions are provided so that the temperature in

In the background a carload of teapots is being drawn from the delivery end of the kiln, while in the foreground two operatives are engaged in cellophane wrapping

HARRIS



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the bottom of the setting can be worked at a lower temperature.

The kiln measures 111 ft. 9 in. from the covered entrance transferway to the exit door, the maximum width over the brickwork of the kiln being 10 ft. 0 in.

The trucks have a chassis 4 ft. 9 in. long carrying refractory and an insulating platform 4 ft. 7 in. long by 3 ft. 8 in. wide, carrying a load 4 ft. 7 in. long, 3 ft. 8 in. wide, and 4 ft. 1 in. high.

The normal schedule for the kiln is nineteen cars per day giving a firing cycle of 27½ hr.

The kiln is fitted with forty horizontal burners, twenty per side, pitched at 1 ft. 6 in., these burners firing under the load. There are, in addition, six vertical burners per side, firing vertically upwards. The burners are divided into three groups, each group controllable by its main gas valve. The two peak temperature groups are under automatic control, this being of the "on and off" type.

The burners are fitted with atmospheric injectors of the Amal type working with cold atmospheric air.

Controls

The instruments, which are of Electroflo Meters Co. Ltd. manufacture, are very complete, and consist of eight thermocouples distributed along the preheating, main, and cooling zones of the kiln, complete with two automatic controllers, one three-point recorder, and a multi point indicator.

The cooling section of the kiln is of the standard cavity panel type, and it is fitted with a ware cooling fan which circulates a large volume of cold atmospheric air in the panels.

The pusher is of the hydraulic type, 5 in. bore worked by a five cylinder submerged variable stroke Greenwood and Batley Pump. It is fitted with 24 hour recorder and adjustable relief valve, and also automatic return gear.

The kiln is fitted with the patented entrance and exit contravecs, each with its own cold air fan.

Decorator Kiln

This kiln is of the fully muffled Gibbons Dressler type, also fired by town's gas, the muffles being of the panel type in glazed carborundum and refractory.

The kiln fires decorated teapots at a temperature of 700 to 800° C., and it has a length of 96 ft. 0 in. overall, the maximum width over brickwork being 8 ft. 0 in.

The cars have a chassis 4 ft. 6 in. long with a loading deck 1 ft. 6 in. wide by 2 ft. 4 in. high by 4 ft. 4 in. long. The decorated teapots are placed on heat-resisting cast-iron bats supported by heat-resisting cast-iron pillars. The kiln is designed for a service of 54 min.

The kiln is fired by four Eddy Ray burners per side, three of these being bottom burners, and the fourth being a top burner. The burners are supplied with cold atmospheric air at 5 in. water gauge by a separate blower. Two contravecs are fitted, one at the entrance, and one at the exit of the kiln each with its separate fan working with cold atmospheric air.

Propelling gear is of the mechanical type fitted with rack and pinion complete with variable speed gear.

The kiln is fitted with a full range of vault thermocouples registering on a three point recorder and a multi indicator, and in addition, an automatic temperature controller operating through the vault thermocouples ensuring correct maintenance of the desired finishing temperature in the tunnel.

Gauge and Tool Exhibition.—The Gauge and Tool Makers' Association is to hold its third Exhibition in the New Hall of the Royal Horticultural Society, Elverton Street, Vincent Square, London, S.W.1, from the 15th-25th May, 1951. It will be open daily except Sunday from 10.30 a.m. to 7 p.m.

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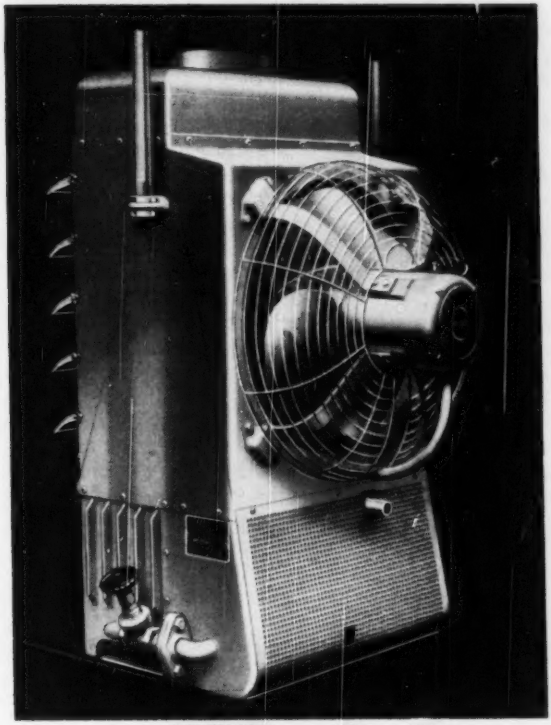

The heating element is made from stainless steel to ensure long life.

They are fitted with automatic control cut outs to render them safe in the event of failure in gas or electrical supplies.

Operation of these units during the normal working period can be simply effected by switching on and off the electrical supply and, therefore, can be satisfactorily controlled by a standard thermostat if required.

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Modern Heat Treatment Furnaces

With Special Reference to Town's Gas Firing

by

L. G. A. LEONARD

FOR an understanding of furnaces and their application it is necessary to appreciate the principles of heat transmission and have a wide knowledge of materials which may be heated by furnaces or used in their construction.

Heat is transmitted by conduction, convection and radiation, but the manner in which it is transferred is so complex that it is often difficult to separate the contribution of the different processes in the total effect.

In conduction, heat moves from one part of a body to another in proportion to the area and the fall in temperature along the length of travel.

Convection and Radiation

Transmission by convection is more complicated, but it is dependent upon a temperature difference which results in motion due to variation of density with temperature. The transmission is influenced by the nature of the flow, whether laminar, turbulent or impinging and by the properties of the heating fluid.

Radiation takes place without material contact between the body emitting and that receiving the heat, the rate being proportional to the difference in the fourth powers of the temperatures of the two bodies. Radiation between the surfaces of solids involves not only the emissivity of the materials, but also geometrical problems. Gases can radiate by themselves, such as H_2O, CO, and CO_2, which absorb and radiate heat rays according to the wave length.

In addition, radiation can take place from particles of soot in luminous flames. Because radiation follows the fourth power law, it is the most important method of heat transfer in industrial furnaces.

These fundamental considerations are associated with furnace performance and operation and materially affect the thermal efficiency.

The combustion of the fuel is primarily the source of heat, but there are some processes involving exothermic reactions which also make a contribution.

The heat developed by the combustion of the fuel may be used for satisfying the following operations:

(1) Heating the charge.
(2) Loss by conduction through walls and dissipation to the surroundings by convection and radiation.
(3) Loss by conduction into the floor on which the furnace is placed.
(4) Loss by incomplete combustion due to incorrect burner settings or to the maintenance of a special atmosphere within the heating chamber. (This may be oxidising or reducing.)
(5) Loss by radiation through openings or from exposed surfaces of melting furnaces.
(6) Loss by the heating of work carriers, conveyors or skid bars, etc.
(7) Loss by leakage into or out of the furnace.

(Paper presented to the Manchester Association of Engineers on 3rd November, 1950.)

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(8) Loss in hot outgoing flue gases.

The above losses hold good for continuous and batch operated furnaces which have reached a state of thermal equilibrium.

The great majority of furnaces, however, are intermittently operated and consequently never reach this steady state.

The heat flow into the charge and walls is variable during a considerable portion of the cycle, and it is therefore necessary to consider the quantity of heat stored by the walls, as this is often much greater than that transmitted into the charge.

Prior to the year 1920, furnaces were built of firebrick or silica, and in order to obtain a reasonably low temperature of the outer wall surface, a considerable thickness of brickwork was employed.

This was fairly satisfactory for continuously operated furnaces, but resulted in great losses when intermittent processes required walls heating again and again for each successive charge. In furnaces of good design, the waste gases passed through ports in the walls so that heat loss was mainly from the hot gases already exhausted from the actual heating chambers. In furnaces fired by hot producer gas the working chambers were frequently wrapped in the hot gas ports, or alternatively, the air ports were made to serve the same purpose. These old ideas are basically sound, and although the need for them is not now so great, they are frequently employed.

Insulation

The introduction of diatomaceous insulation enabled much thinner walls to be used with a lower external surface temperature and heat loss.

Originally it was the practice to use no more than 2½ in. of insulation, but gradually the thickness increased until today it is quite common to find continuous operated furnaces with as much as 9 in. or 13½ in. of insulation between the firebrick linings and the steel casings.

The savings in the wall losses made possible by the use of diatomaceous insulation as a backing material for firebrick vary from about 40 per cent. to 80 per cent. with continuous operation, and from 15 per cent. to about 35 per cent. for intermittent operation. It will be appreciated that this saving is dependent upon the thickness and quality of the insulation used and upon the thickness of the firebrick wall.

Insulating Refractory

The next step in insulating technique occurred about 1935 with the introduction of lightweight insulating refractory instead of firebrick for the inner walls of furnaces operating at temperatures below 1,200° C.

At first, laboratory and small oven furnaces were built from it, but as confidence increased, the size of the furnaces gradually became larger, until today it is used for installations as much as 20 ft. wide and of comparative height with no restriction in length. The material is similar in its physical characteristics to normal firebrick, except that it is cellular and, consequently, its weight and thermal conductivity are much less than those of firebrick.

The "lightweight" or "hot face insulating firebrick" is most economically employed in the construction of intermittent furnaces, as the amount of heat stored by walls is reduced as the weight of the brickwork is decreased. Some very large furnaces have been built of this material in which the rate of heating from cold is so fast that the walls are only flash heated when the operation is completed. Insulating refractories normally weigh about 40-45 lb. per c. ft., which can be compared with firebrick weighing 130 lb. per c. ft. Recently there

have been introduced insulating refractories made from the micaceous mineral known as vermiculite. These are available in slab form with a density as low as 30 lb. per c. ft., and a correspondingly low thermal conductivity. It is, therefore, now possible to build batch or intermittently operated furnaces with thermal efficiency not much lower than that which can be achieved in continuous furnaces. The use of slabs instead of bricks reduces the loss of heat through joints and the possibility of leakage into or out of the furnace. Normal dense firebrick is superior in strength and resistance to mechanical or chemical attack, and is therefore used for the base of furnaces where heavy loads must be carried.

When insulating refractory is subjected to the scrubbing action of hot gases, it is covered on its hot face with a layer of high temperature resisting cement applied in the form of a plaster. This gives effective protection, and by sealing the surface pores prevents leakage which might otherwise occur through porosity.

Burners

Many low-temperature furnaces have "natural draught" burners which rely upon the flue and the pressure of the gas to provide air for combustion. There are a multitude of types, but the most popular is the atmospheric injection burner.

Because furnaces are employed at relatively high temperatures, the great majority employ air-blast burners which are manufactured in a number of types and applied in a variety of ways.

The air and gas streams may be at comparatively low pressures and the mixing slow enough to promote long luminous flames. Such combustion systems are used in steel billet and slab heating furnaces where the long luminous flames fire horizontally above the steel being heated, and are an advantage as they condition the steel for rolling by giving it a soft scale which breaks away in the rolls.

In heat treating furnaces designed for this system luminous flames are applied as vertical curtains on each side of the hearth, and the air for combustion is preheated by the waste gases.

Tunnel Burners

Another basic type is the tunnel burner firing through the side walls and so spaced that burners on one side fire between those on the opposite wall. They may be arranged to fire under the hearth or above the charge.

In the simplest form these burners are supplied with air and gas completely mixed by an automatic proportioning inspirator or by a mixing machine. Their limitation is the low turn-down ratio which is seldom more than four to one, but they have the great advantage of automatic proportioning of the air-gas mixture throughout the range of operation. The combustion is confined to the tunnels within the walls so that the furnace and its charge are heated by hot gases.

The nozzle mixing burner with annular concentric air and gas pipes is a variety which can be designed to suit almost any pressure of air or gas. The air-gas ratio is dependent upon the judgment of the operator, but the burner cannot back-fire. Because the mixing only takes place at the nozzle, the combustion is not confined to the tunnel within the wall, and the flame projects into the furnace chamber,

An improved design is the combined-inspirator type which essentially consists of a venturi proportioning device built in the form of a burner. This has the wide turn-down advantage of the nozzle mixing type combined with automatic proportioning, but it is more expensive than an ordinary tunnel burner. The disadvantage is that each burner must be individually set and this

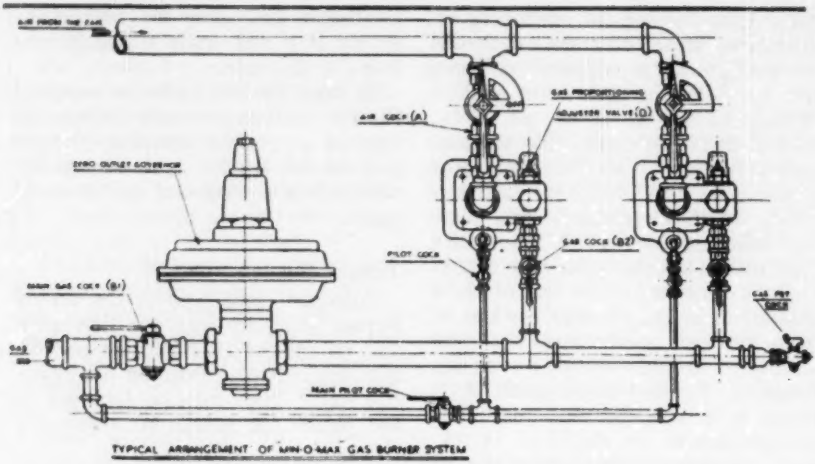

Fig. 1. Typical arrangement of automatic proportioning burner system

operation can be somewhat tedious where large numbers are employed, as on continuous wire patenting furnaces or large bogie annealing furnaces.

Once set, the burners do not require further adjustment to maintain the correct air-gas ratio, and it is only necessary to adjust the air valve to alter the rate of burning. Correctly adjusted they prevent loss of heat by incomplete combustion. (Fig. 1.)

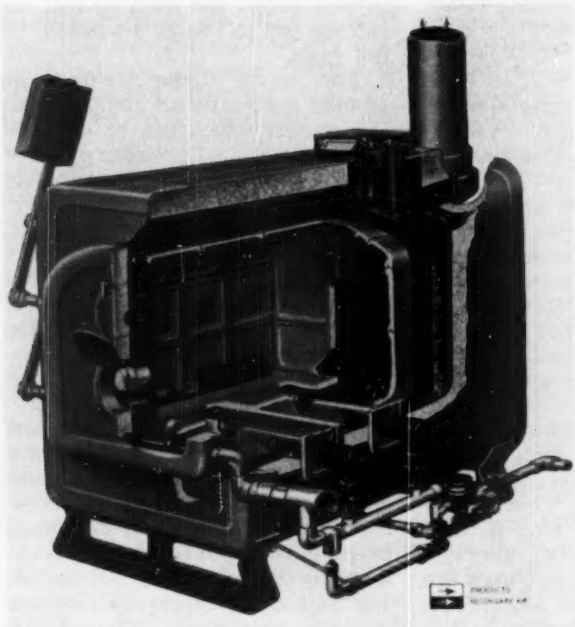

Fig. 2. Natural draught gas-fired pottery kiln with muffle and tubular recuperator elements

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Uniform heat distribution is assisted by the correct positioning of flues which preferably should be placed below the level of charge so that the furnace is completely filled with products of combustion.

In oven furnaces, flues in the door openings tend to prevent the inrush of air into the working chambers when the doors are opened. They also ensure the gases of combustion pass longitudinally through the working chamber in addition to the circulation set up by burners firing through the side walls. This is of assistance in obtaining uniformity of temperature.

In continuous furnaces the flues are usually arranged at the inlet end so that the gases of combustion are cooled by the incoming material, thereby improving the thermal efficiency. A portion of the heat lost in the flue gases may be salvaged by the use of a recuperator or regenerator for preheating the air for combustion. As the temperature of the furnace increases so does the operation become more profitable.

Town's gas-fired furnaces must frequently make use of recuperators in preference to regenerators because there is less thermal storage, and the majority of gas furnaces are intermittently operated. The recuperator elements may take the form of refractory or metallic tubes of round, square or rectangular section.

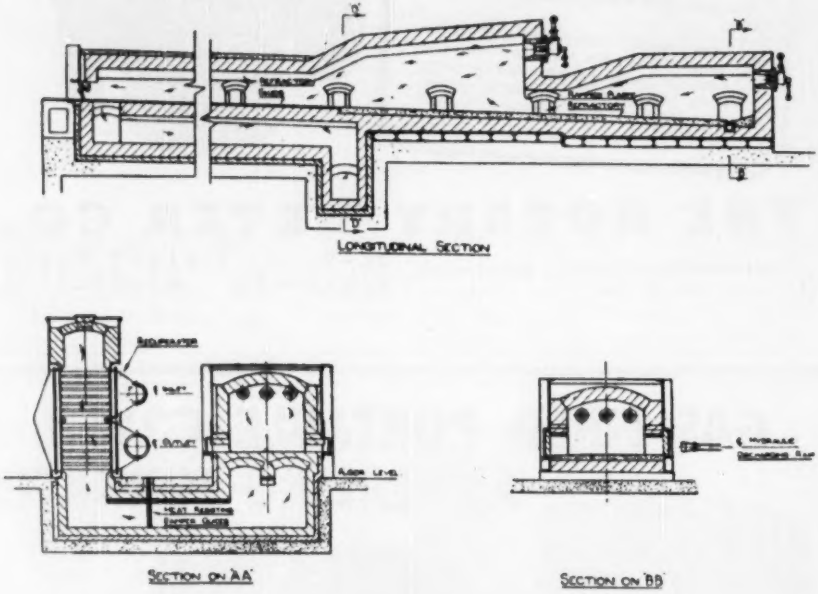
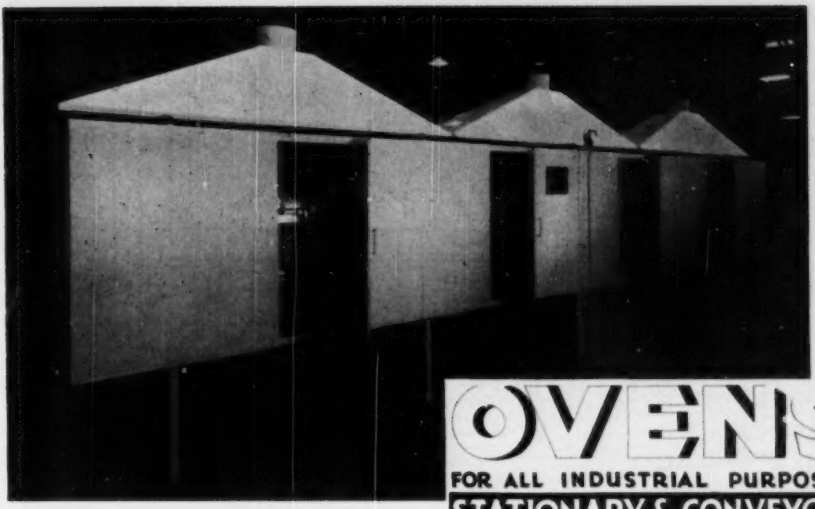


Fig. 3. Diagram of town's gas-fired billet furnace

Firebrick refractory elements suffer from the disadvantage of the low conductivity of the material and the possibility of leakage through joints or cracks.

Silicon carbide tubes have overcome these disadvantages and are used for high temperature. (See Fig. 2.) The metallic recuperator element can be arranged in the form of a thimble outer tube blocked at one end, with an inner tube delivering the air to the closed end and at the same time acting as a core buster. The air passes between the



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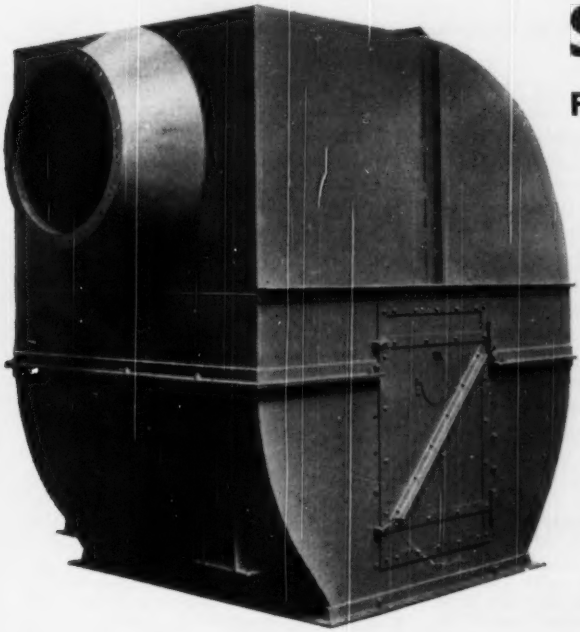

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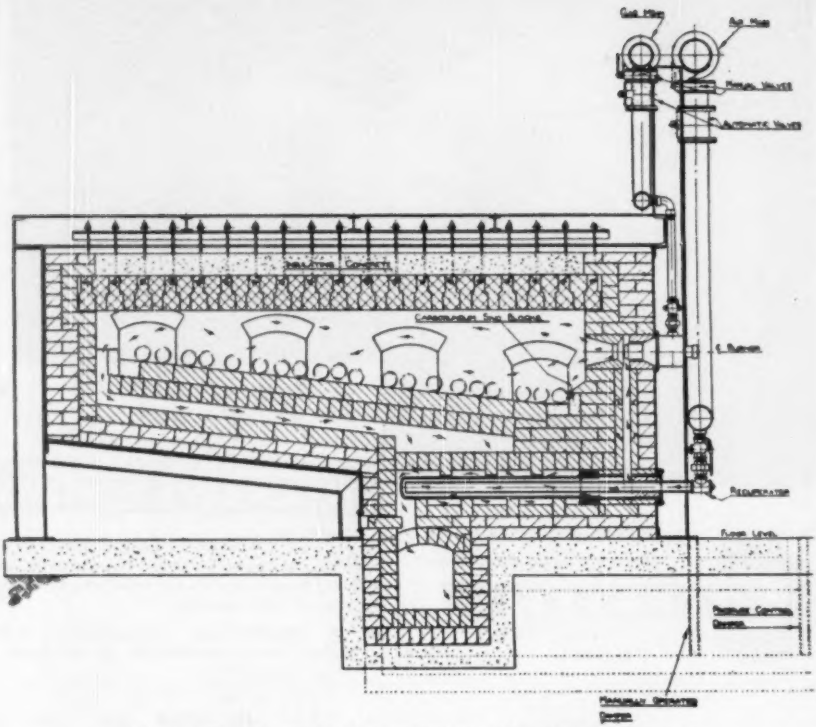

Fig. 4. Town's gas-fired recuperative tube reheating furnace

inner and outer tubes towards the inlet end. Nests of these tubes can be hung vertically to form a common large unit, or alternatively, one element may be arranged to feed one burner. (See Fig. 4.)

A popular form of metallic recuperator has elements with oval cross-sections and needles cast on the inner and outer wall surfaces. These needles increase the rate of heat transmission per sq. ft. and thereby reduce the size of the recuperator as compared with what would be required if needles were absent. It is a recuperator of this design shown in Fig. 3.

Other methods of heat salvage from hot flue gases include the waste heat boiler and the use of the gases for some other low temperature operation. Instances are drying ovens heated by the waste gases from galvanizing furnaces or drying rooms heated by gases from enamelling furnaces.

(To be continued.)

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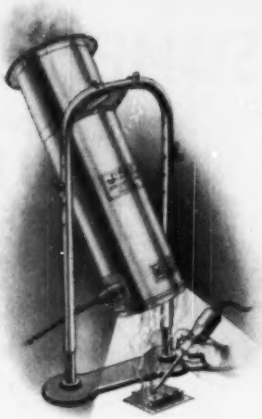
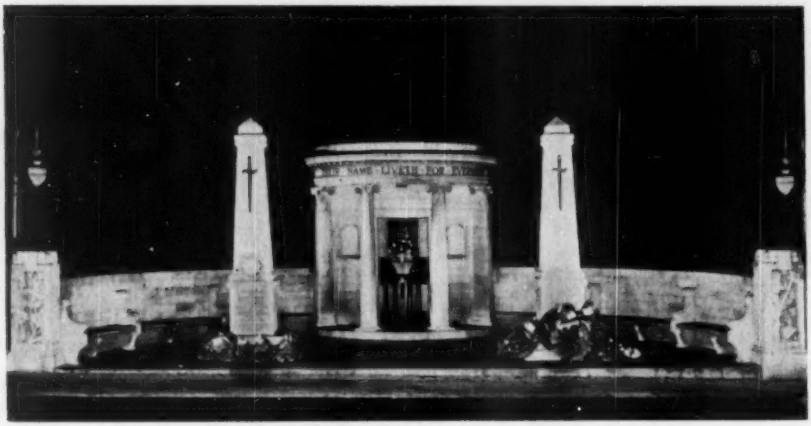


FLOODLIGHTING BY GAS

BEDFORD was honoured by the presence of Her Majesty the Queen on 11th November, when she unveiled and dedicated the war memorial obelisk, at Kempston Barracks, to the members of the Bedfordshire and Hertfordshire Regiment who died in the second World War of 1939-1945.

By night the beams of gas floodlighting revealed new beauty and dignity to the memorial. In a letter received by the Bedford District of the Cambridge Division, the thanks of Lieutenant-General Sir Reginald Denning, K.B.E., C.B., and the Regiment were expressed to the Bedford staff for the beautiful effect of the floodlighting, which Her Majesty the Queen was able to see and admire before her departure.

The gas floodlighting was carried out by means of nine 8-light No. 1 Edgar Vertiflood lamps, and two Foster Fulham 10-light No. 2 lamps.



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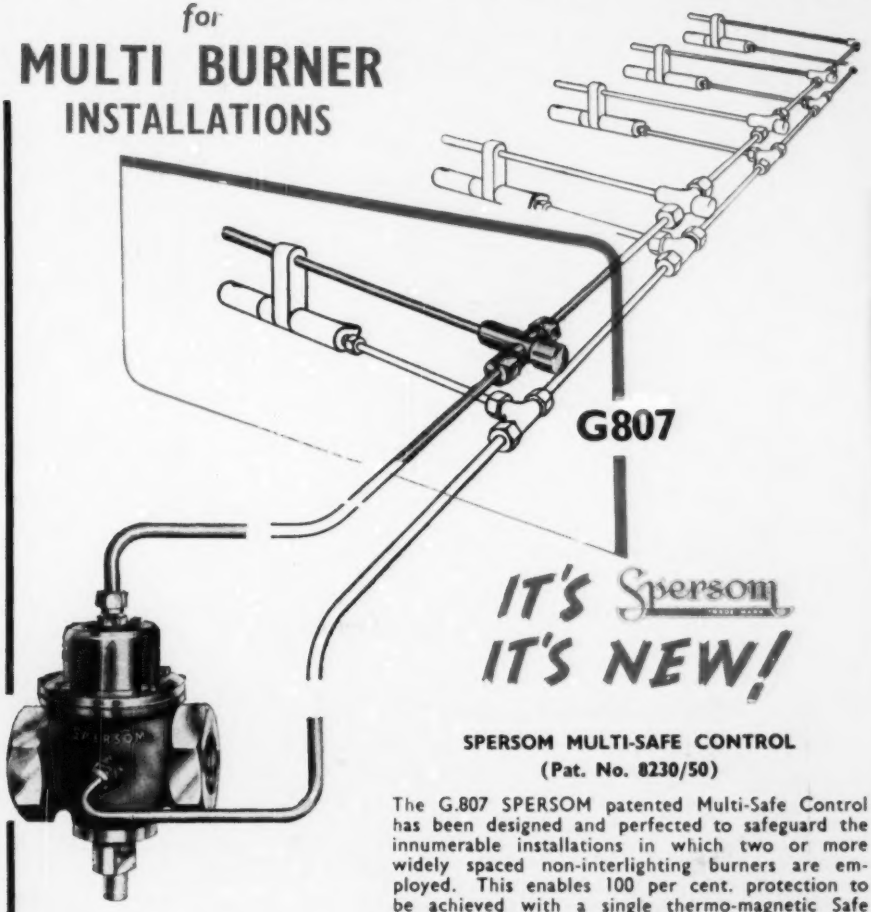
for

MULTI BURNER INSTALLATIONS

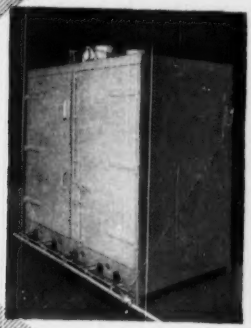


IT'S Spersom
IT'S NEW!

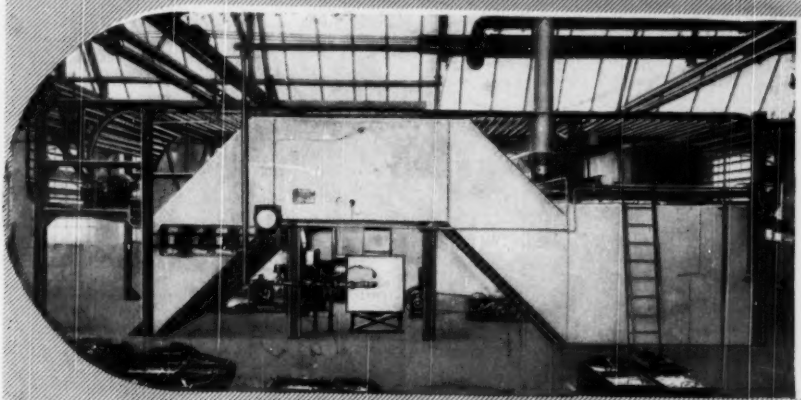
SPERSOM MULTI-SAFE CONTROL
(Pat. No. 8230/50)

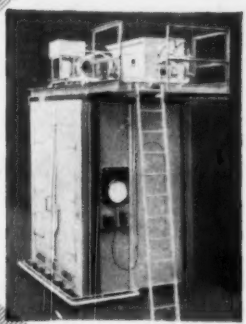
The G.807 SPERSOM patented Multi-Safe Control has been designed and perfected to safeguard the innumerable installations in which two or more widely spaced non-interlighting burners are employed. This enables 100 per cent. protection to be achieved with a single thermo-magnetic Safe Control Pilot by the addition of one SPERSOM G.807 Multi-Safe Control and one pilot burner unit for each main burner. By utilising this system, should the flame fail at any one burner it will either be reignited by the pilot burner or, if the pilot burner has also failed, the G.807 Multi-Safe Control will cause the main gas supply to be cut off from the whole of the apparatus. We shall be pleased to forward our pamphlet upon request.

SPERRYN & CO., MOORSOM ST., BIRMINGHAM 6



FOR INDUSTRIAL OVENS OF ALL TYPES





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